Bone Block Graft Fixation for Glenoid Bone Loss: A Comparative Study of FiberTape® Cerclage vs Endobutton Constructs

Arthrex Product Management and Orthopedic Research

Objective

Anterior shoulder instability is a common consequence of traumatic shoulder injuries and is often associated with glenoid bone loss.[1] In a clinical study with 91 patients being surgically treated for traumatic, recurrent anterior instability, a glenoid osseous lesion was found in 49% of the cases.[2] Autogenic or allogenic bone block grafts have been established as a reliable substitute to cover the glenoid bone defect, with increasing treatment frequency in recent years.[3] The purpose of this testing was to compare 2 fixation methods for glenoid bone loss applications with regard to cyclic loading and graft interface pressure:

- Metal-free fixation with 2.4 mm tunnels and 2 interconnected FiberTape cerclage sutures (Arthrex)
- Suture-button fixation using round Endobuttons, 1-hole and 2-hole with post, with 2.8 mm tunnels (Smith & Nephew)

Both configurations were tested for biomechanical stability (n = 6 in each group) by measuring minimum initial elongation at 325 N, and load at both 3 mm and 5 mm displacements. These parameters were chosen because 3 mm represents the common threshold for clinical failure and 5 mm was defined as a threshold in previous literature.[4]

Furthermore, both configurations (n = 6 in each group) were tested for pressure distribution in the contact area between the glenoid and the small bone block.

Methods and Materials

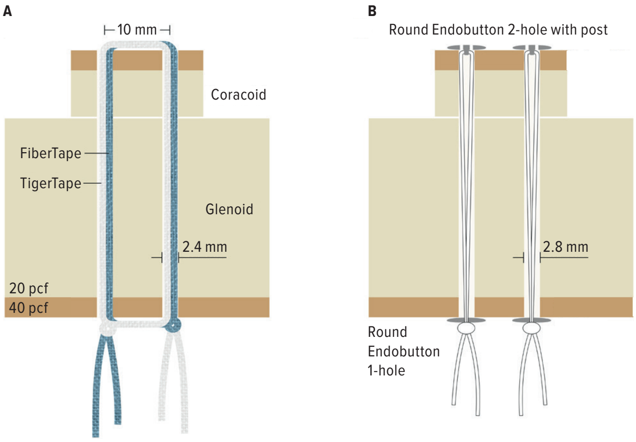
For this purpose, two 20/40 Sawbones blocks representing the glenoid (30 mm × 30 mm × 40 mm) and a small bone block (10 mm × 10 mm × 20 mm) were prepared. Drill holes were predrilled 10 mm apart with a diameter of 2.4 mm for FiberTape cerclage fixation (group 1) and 2.8 mm for Endobutton fixation (group 2), according to the surgical techniques.

Preparation of FiberTape Cerclage Constructs (Group 1)
For FiberTape cerclage constructs, the FiberTape and TigerTape™ cerclage suture tails were threaded from the bottom to the top through the drill hole in the glenoid and small bone block and then back through the second drill holes to press the small bone block to the glenoid (see Figure 1.A).

As described in the surgical technique, to interconnect both cerclage sutures, the FiberTape cerclage suture tail was loaded through the pre-tied racking hitch knot of the TigerTape cerclage suture and, consequently, the TigerTape cerclage suture tail was loaded through the pre-tied racking hitch knot of the FiberTape cerclage suture.[5] Once the tape portion of each suture engaged the knots, the sutures were then individually and sequentially hand-tightened to reduce the slack in the construct. The FiberTape and TigerTape suture tails were successively loaded into the FiberTape cerclage tensioner and the knots were tensioned to a load of 80 lbf. Then the suture ends were cut to separate the 2 tails of the cerclage sutures. Three alternating half hitches were made on each cerclage suture.

Preparation of Endobutton Constructs (Group 2)
For suture-button constructs using round Endobuttons (see Figure 1.B), as described in the surgical technique, both devices were threaded through the small bone block and then through the glenoid until the 2-hole Endobutton with post lay flat on the anterior side of the bone block.[6] The continuous loops were threaded through the posterior buttons and then 1 loop was cut to separate the 2 ends. The posterior round 1-hole Endobuttons were advanced until they sat flush against the posterior face of the glenoid using a double-sutured Nice knot.[7] Using the FiberTape cerclage tensioner, 80 lbf of tension was applied to each knot and then 3 alternating half hitches were applied to each suture.

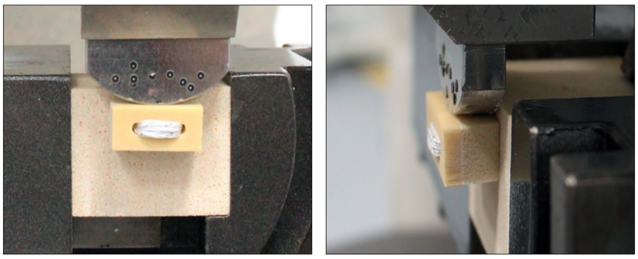
Figure 1.A: FiberTape® cerclage construct with 2 interconnected cerclage sutures (1 FiberTape and 1 TigerTape™ cerclage suture).
Figure 1.B: Suture-button construct with Endobuttons.



Biomechanical Testing

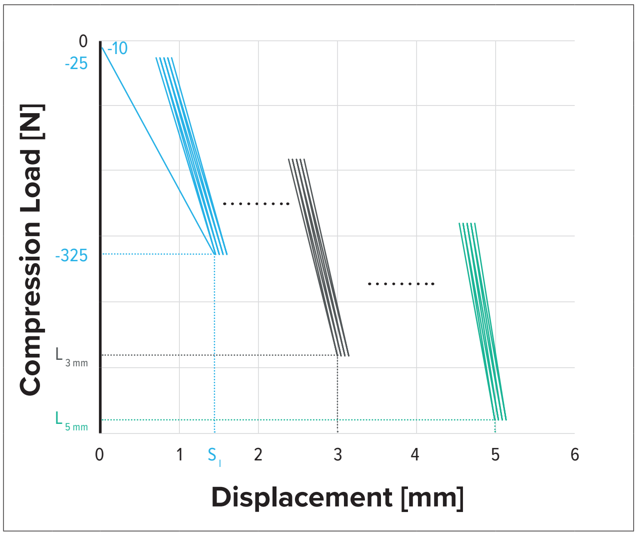
The Sawbones blocks were mounted to the testing system (Instron E3000). The load was applied with a customized stamp, which was flush with the front of the glenoid, replicating the curvature of the humeral head (see Figure 2).

Figure 2: Test setup for biomechanical testing.



The test setup was chosen to follow the procedure described in previous literature by Alvi et al.[8] The displacement was set to 0 mm at a preload of 10 N. Cyclic compression loading at 0.25 mm/s was applied initially between 25 N and 325 N. The peak-to-peak amplitude of 300 N was kept constant during testing, but both the minimum and maximum load were increased by 25 N every 20th cycle until failure or a maximum compression load of 1000 N was reached. Load and displacement data were recorded at 500 Hz. The initial elongation (S_I) and the load at 3 mm ($L_{3\ mm}$) and 5 mm ($L_{5\ mm}$) displacement were evaluated as depicted in Figure 3. Failure was defined by Shin et al[4] as 5 mm of displacement of the graft interface. Moreover, a minimum load value of 375 N was defined at 5 mm displacement as an acceptance criterion, according to the findings of Bergmann et al.[9] The glenohumeral contact forces in 45° abduction without a weight in hand results in 375 N, based on 51% body weight for a subject of 75 kg.

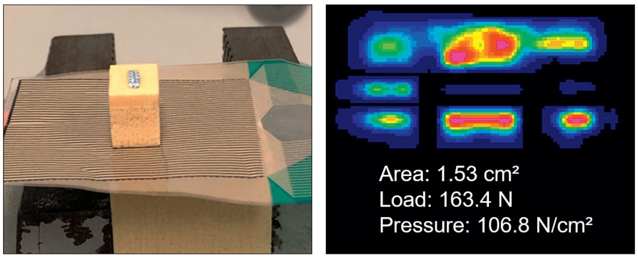
Figure 3: Schematic load-displacement graphic with display of initial elongation (S_I), and load at 3 mm ($L_{3\ mm}$) and 5 mm ($L_{5\ mm}$) displacement.



Interface Pressure Testing

Using a TekScan I-Scan pressure mapping system, the pressure mapping sensor (model number 5051, max pressure 3447 kPa) was calibrated and 2 holes were cut into the sensor 10 mm apart. The sensor was then placed between the small bone block and the glenoid (Figure 4) prior to the previously described sample preparation. The final force and loaded area were measured and noted to calculate the resulting contact pressure.

Figure 4: Test setup for pressure distribution measurement in the contact area of glenoid and small bone block using the TekScan 5051 sensor (left) with corresponding measurement values (right).



Results

Biomechanical Testing[10,11]

The minimum initial elongation and the load at 3 mm and 5 mm can be seen with the corresponding *P* values from the *t* test in Figures 5 and 6. The mean minimum initial elongation (S_I) for the FiberTape® cerclage fixation technique (1.80 mm ± 0.32 mm) was significantly lower than the mean minimum SI for the suture-button fixation technique (2.87 mm ± 0.56 mm, $P = .002$). The load at 3 mm displacement ($L_{3\ mm}$) for the FiberTape cerclage fixation technique (430 N ± 29 N) was significantly higher than the load at L_{3mm} for the suture-button fixation technique (326 N ± 49 N, $P =$ .008). Similarly, the load at 5 mm displacement ($L_{5\ mm}$) for the FiberTape cerclage fixation technique (592 N ± 9 N) was significantly higher than the L_{5mm} for the suture-button fixation technique (518 N ± 62 N, $P = .035$). The load at 5 mm displacement for both constructs was significantly higher than the acceptance criteria of 375 N (FiberTape cerclage, $P < .0001$; suture-button, $P =$ .0025). Both groups showed no construct failure before 5 mm displacement was reached.

Figure 5: Minimum initial elongation (S_I) at 325 N during biomechanical testing with corresponding *P* value; n = 6.

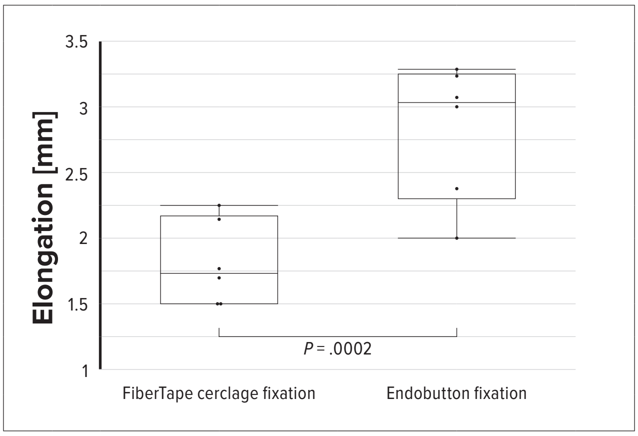
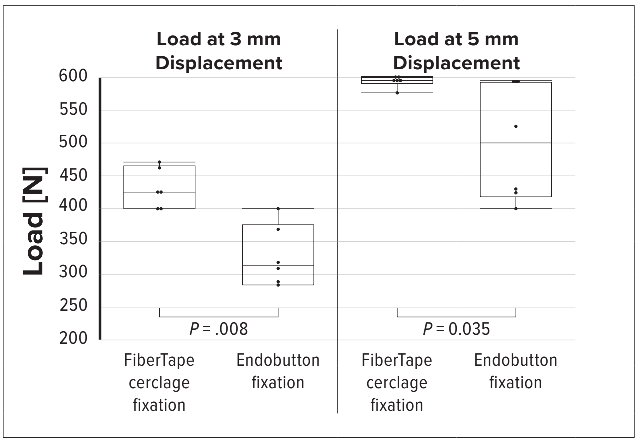


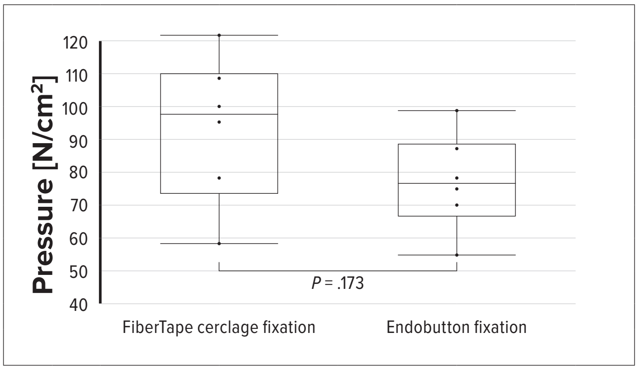
Figure 6: Load at 3 mm ($L_{3\ mm}$) and 5 mm ($L_{5\ mm}$) displacement during biomechanical testing with corresponding *P* value; n = 6.



Interface Pressure Testing

The contact pressure can be seen in Figure 7. The contact pressure for the FiberTape cerclage fixation technique (93.2 N/cm² ± 21.8 N/cm²) was higher than the contact pressure for the suture-button fixation technique (77.3 N/cm² ± 14.8 N/cm²). However, no statistically significant difference was observed ($P = .173$).

Figure 7: Contact pressure with corresponding *P* value; n = 6.



Conclusions

The FiberTape cerclage fixation technique shows a significantly lower minimum initial elongation as well as higher loads at 3 mm and 5 mm displacement Therefore, it can be concluded that the FiberTape cerclage fixation technique can better withstand construct displacement at higher loads. Both constructs met the defined acceptance criteria for the load at 5 mm displacement, with each load significantly exceeding 375 N.

The FiberTape cerclage fixation technique and the suture-button fixation technique show statistically equal contact pressure between the small bone block and the glenoid. We conclude that both techniques are clinically safe with regard to the contact pressure.

References

1. Lynch JR, Clinton JM, Dewing CB, Warme WJ, Matsen FA 3rd. Treatment of osseous defects associated with anterior shoulder instability. *J Shoulder Elbow Surg.* 2009;18(2):317-328. doi:10.1016/j.jse.2008.10.013
2. Boileau P, Villalba M, Héry JY, Balg F, Ahrens P, Neyton L. Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. *J Bone Joint Surg Am.* 2006;88(8):1755-1763. doi:10.2106/JBJS.E.00817
3. Degen RM, Camp CL, Werner BC, Dines DM, Dines JS. Trends in bone-block augmentation among recently trained orthopaedic surgeons treating anterior shoulder instability. *J Bone Joint Surg Am.* 2016;98(13):e56. doi:10.2106/JBJS.15.01478
4. Shin JJ, Hamamoto JT, Leroux TS, et al. Biomechanical analysis of Latarjet screw fixation: comparison of screw types and fixation methods. *Arthroscopy.* 2017;33(9):1646-1653. doi:10.1016/j.arthro.2017.03.030
5. Hachem AI, Del Carmen M, Verdalet I, Rius J. Arthroscopic bone block cerclage: a fixation method for glenoid bone loss reconstruction without metal implants. *Arthrosc Tech.* 2019;8(12):e1591-e1597. doi:10.1016/j.eats.2019.08.014
6. Taverna E, Golanò P, Pascale V, Battistella F. An arthroscopic bone graft procedure for treating anterior-inferior glenohumeral instability. *Knee Surg Sports Traumatol Arthrosc*. 2008;16(9):872-875. doi:10.1007/s00167-008-0541-y
7. Boileau P, Alami G, Rumian A, Schwartz DG, Trojani C, Seidl AJ. The doubled-suture Nice knot. *Orthopedics*. 2017;40(2):e382-e386. doi:10.3928/01477447-20161202-05
8. Alvi HM, Monroe EJ, Muriuki M, Verma RN, Marra G, Saltzman MD. Latarjet fixation: a cadaveric biomechanical study evaluating cortical and cannulated screw fixation. *Orthop J Sports Med.* 2016;4(4):2325967116643533. doi:10.1177/2325967116643533
9. Bergmann G, Graichen F, Bender A, Kääb M, Rohlmann A, Westerhoff P. In vivo glenohumeral contact forces—measurements in the first patient 7 months postoperatively. *J Biomech.* 2007;40(10):2139-2149. doi:10.1016/j.jbiomech.2006.10.037
10. Arthrex GmbH. Data on file (APT-G01159). Munich, Germany; 2020.
11. Arthrex GmbH. Data on file (APT-G01160). Munich, Germany; 2020.

arthrex.com

Arthrex®